

Title	Go, Score, Win with Physics		
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Source:	2009 TLI Staff PBL Plans		
Project Idea:	Student groups act as consultants to coaches and athletes of a particular sport by creating a documentary video, analyzing the component forces and motions and using physics to justify the use of various techniques to gain a competitive edge.		
Entry Event:	Students view a brief game clip of one of the school's sports' teams followed by a brain-storming session on physics concepts involved in the sport. Then students are presented a Memo to Sports Consulting Teams explaining that their team is to act as a sports consultant agency to prepare a documentary to help coaches and athletes use physics to gain a competitive edge.		
Content Standards & Objectives:	Objectives Directly Taught or Learned Through Discovery	Identified Learning Target	Evidence of Success in Achieving Identified Learning Target
	SC.O.P.1.3 conduct and/or design investigations that incorporate the skills and attitudes and/or values of scientific inquiry (e.g., established research protocol, accurate record keeping, replication of results and peer review, objectivity, openness, skepticism, fairness, or creativity and logic).	Scientific method, control of variables, use of data tables.	Projectile motion lab with video analysis Graphical Analysis Rubric .
	SC.O.P.1.5 draw conclusions from a variety of data sources to analyze and interpret systems and models (e.g., use graphs and equations to measure and apply variables such as rate and scale, evaluate changes in trends and cycles, predict the influence of external variances such as potential sources of error, or interpret maps).	Design and do a motion experiment involving manipulation of a variable.	Motion analysis evaluated using Graphical Analysis Rubric .
	SC.O.P.2.1 construct and interpret graphs of position versus time, velocity versus time and acceleration versus time.	Vocabulary: velocity; acceleration; slope Basic graphing skills Distinguish independent and dependent variable Determine meaning of slope	Self evaluation using Knowledge Rating Scale . Checklist for Basic Line Graphing Skills . Motion analysis (see Step 5 in Manage the process for details) evaluated using Graphical Analysis Rubric .
	SC.O.P.2.2 appraise data, either textbook generated or laboratory collected, for motion in one and/or two dimensions then select the correct mathematical method for communicating the value of unknown variables.	Basic mathematical relationships – direct, inverse, inverse square. Relationships among y-value, slope, and area under curve.	Projectile motion lab with video analysis Graphical Analysis Rubric .

	<p>SC.O.P.2.5 Justify Newton's Laws of Motion in terms of equilibrium and net force situations.</p>	<p>Vocabulary: equilibrium; net force Application of vector mathematics Vector addition Understanding of Newton's Laws of Motion Do an experiment involving forces.</p>	<p>Teacher-made constructed response exercise Addition of Forces FAT-P Addition of Force Lab Report Rubric. Motion analysis evaluated using Graphical Analysis Rubric.</p>
	<p>SC.O.P.2.18 Analyze the motion of a projectile.</p>	<p>Measurement, graphing Mathematical relationships Vocabulary: constant velocity; constant acceleration; horizontal; vertical Do an experiment involving motion of a projectile.</p>	<p>Projectile motion lab with video analysis Graphical Analysis Rubric. Also: Motion of a Projectile Lab, use Part A: Projectile Motion (Motion of a Dart) * Additionally, all objectives will also be evaluated in final group product using the Documentary Video Rubric.</p>

21st Century Skills	Learning Skills & Technology Tools	Teaching Strategies Culminating Activity	Evidence of Success
Information and Communication Skills:	<p>21C.O.9-12.1.TT4 - Student uses audio, video, pictures, clip art, moviemaker programs, webpage design software, electronic documents and other files to collaborate for the creation of electronic products that inform multiple audiences both inside and outside the school environment.</p>	<p>Teacher facilitates as students incorporate analyses from lab investigations into multimedia presentation that effectively communicates concepts and relationships to appropriate audience.</p>	<p>Documentary Video Rubric</p>
Thinking and Reasoning Skills:	<p>21C.O.9-12.2.LS2 - Student draws conclusions from a variety of data sources to analyze and interpret systems.</p> <p>21C.O.9-12.2.TT2 - Student collaborates with peers, experts and others to contribute to a content-related knowledge base by using technology to compile, synthesize, produce, and disseminate information, models, and other creative works.</p>	<p>Teacher facilitates as students draw conclusions from data collected from projectile motions labs using video analysis as well as traditional measuring tools.</p> <p>Teacher facilitates as students use digital cameras and video analysis software to investigate relationships between position, velocity, acceleration and time.</p>	<p>Motion analysis evaluated using Graphical Analysis Rubric.</p> <p>Content portion of Documentary Video Rubric will be used for final group product.</p>

Personal and Workplace Skills:	21C.O.9-12.3.LS6 - Student maintains a strong focus on the larger project goal and frames appropriate questions and planning processes around goal. Prior to beginning work, student reflects upon possible courses of action and their likely consequences; sets objectives related to the larger goal; and establishes benchmarks for monitoring progress. While working on the project, student adjusts time and resources to allow for completion of a quality product.	Teacher facilitates as student teams create a group contract to outline protocols and consequences. Teacher facilitates as student teams create and maintain task charts for their group.	Self-evaluation of contract and task charts. Use the task charts as a checklist for group accomplishments. Teacher observation and monitoring.
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Performance Objectives:	<p>Know Students will know: Vocabulary and usage for these terms: position, velocity, acceleration, slope, force. The relationships shown by slope and area on graphs Newton's Laws of Motion</p> <p>Do Students will be able to: Operate digital cameras to take still photos and video Construct and interpret motion graphs Utilize video analysis software Add vectors Use software to create movies Analyze forces Predict the effect of variables on pathways of motion Apply Newton's Laws of Motion to sports and to projectile motion.</p>
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Driving Question:	How can forces influence motion to give athletes the winning advantage in a sport?
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Assessment Plan:	Major Group Products	Documentary video (showing how physics is involved and can be used for a competitive edge in a particular sport.)
	Major Individual Projects	Motion of a Toy Car (analysis practice) Addition of Force Lab Report Projectile Motion Lab Report Video analysis of one motion that is a component of a particular sport Written response to Addition of Forces FAT-P

Assessment and Reflection:	Rubric(s) I Will Use:		Collaboration Collaboration Rubric	X	Written Communication	
			Critical Thinking & Problem Solving Reasoning Skills Rubric	X	Content Knowledge Graphical Analysis Rubric Projectile Motion Laboratory Rubric Addition of Forces Laboratory Rubric Documentary Video Rubric	X
			Oral Communication		Other	

	Other Classroom Assessments For Learning:	Quizzes/Tests		Practice Presentations	
		Self-Evaluation		Notes	
		Peer Evaluation Documentary Video Rubric	X	Checklists/Observations Checklist for Basic Line Graphing Skills	X
		Online Tests and Exams		Concept Maps	
	Reflections:	Survey		Focus Group	
		Discussion Discussion Rubric	X	Task Management Chart Task Management Chart (for Teams)	X
		Journal Writing/Learning Log		Other: Debriefing Responses Self Reflection	X

Map The Product:

Each team will investigate a different sport, based on interest. Teams will identify major component motions within the chosen sport and assign one motion to each team member. Each individual team member will videotape the assigned/selected motion and complete a motion analysis. Team members may assist each other. The team uses the individually collected data and analyses to create a documentary video. The video must explain the physics applications involved in the sport and address how physics and knowledge of physics can be used to improve athletic performance. In the process, each team member becomes an “expert” on one motion. The team collaborates in order to identify common themes and patterns to highlight in their video.

Product: [Documentary video](#) (intended to help coaches and athletes in particular sports use physics to gain a competitive edge).

Knowledge and Skills Needed	Already Have Learned	Taught Before the Project	Taught During the Project
1. Graphing skills	X		
2. Vocabulary: velocity; acceleration; slope; force; momentum; etc.	X		X (as needed)
3. Use of video analysis and video production software			X (as needed)
4. Use of digital cameras and voice recorders			X (as needed)
5. Addition of vectors			X
6. Principles and applications of Newton's Laws of Motion			X
7. Principles and applications of projectile motion			X

Resources:

School-based Individuals:

Coaches and athletes
Library/Media Specialist
Technology Integration Specialist

Technology:

Video cameras
Digital cameras
Video analysis software (optional)
Video production software (e.g. Windows Movie Maker)
Digital voice recorder (optional)
Computers

Optional Web Resources:

Vector Addition: $6 + 8 = ?$ <http://www.glenbrook.k12.il.us/GBSSCI/PHYS/mmedia/vectors/va.html>

SASinSchool Web Inquiry 79: What are vectors and what is vector algebra
<http://www.sascurriculumpathways.com/ProductEntrance/Launch/launch.jsp?unit=79>
 SASinSchool Web Lesson 486: Projectile Motion
<http://www.sascurriculumpathways.com/ProductEntrance/Launch/launch.jsp?unit=486>
 SASinSchool Web Resources 708: Internet Sites (related to force and motion)
<http://www.sascurriculumpathways.com/ProductEntrance/Launch/launch.jsp?unit=708>
 Vector tutorial <http://www.physicsclassroom.com/Class/vectors/u3l3a.cfm>

Some Links for the Physics of Sports:

Soccer

<http://physicsworld.com/cws/article/print/1533>
http://findarticles.com/p/articles/mi_m0EIN/is_2001_August_13/ai_77136648
<http://www.soccerballworld.com/Physics-FAQ.htm>
<http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/newton/soccer09.html>

Football

<http://entertainment.howstuffworks.com/physics-of-football.htm>
<http://www.popularmechanics.com/outdoors/sports/4212171.html>
<http://www.edwardwillett.com/Columns/footballphysics.htm>
<http://pr.caltech.edu:16080/periodicals/CaltechNews/articles/v37/tacklingphysics.html>

Softball/Baseball

<http://www.pitchsoftball.com/AllPitchesHaveanArc.html>
<http://www.kettering.edu/~drussell/bats.html>
<http://www.wooster.edu/physics/JrIS/Files/Triplett.pdf>
<http://webusers.npl.illinois.edu/~a-nathan/pob/>

Community:

Coaches and athletes

Local physicists

Materials:

Blank CDs or DVDs

Sports equipment

Toy dart guns or rubber band guns (or similar projectile)

Stop-watches

Spring scales or force sensors

Variety of weights

Manage the
Process:

Step 1: Arrange students into groups of four based on interest in a particular sport. (Teachers may use an interest survey or personal knowledge of student participation and interest in sports for this grouping.)

Step 2: Present entry event. Show one or more short game clips, preferably ones that feature members of the class. Present teams with the [Memo to Sports Consulting Teams](#).

Step 3: Allow student teams to meet initially and periodically to complete and update [Task Management Charts](#). At the initial meeting, teams should create a group contract, select four motions from their selected sport, and decide who will be responsible for the analysis of each motion.

Step 4: Optional: Use a graphical analysis activity such as [The Motion of a Toy Car](#) activity to assess students' readiness for the tasks that follow.

Step 5: Individual students videotape the selected motions. Students create distance-time graphs for these motions. (This can be done using video analysis software. If this software is not available, graphs may be created using data collected manually. To do this, play the video frame by frame, recording time from the video player software and measure distance from a reference point on the screen. Water soluble markers may be helpful. For either method, a means of determining scale is essential. There must be an object in the video that is physically measured to be used to convert video size to real-world size. This could be a piece of equipment e.g. a baseball bat or a person's height or other object in video.) The created graphs should be analyzed and evaluated using the [Graphical Analysis Rubric](#).

Step 6: Students begin video analyses of the individual motion and work on group product (documentary video) on ongoing basis. Plan to address critical concepts as needs arise in the student-directed research and analysis. These can be addressed by taking breaks from team work in order to do more traditional lab work. At points in the process, students will need to apply concepts involving Newton's Laws, addition of forces, and motion of projectiles. Students should have prior experience with basic motion labs involving displacement, velocity, acceleration and time. During the PBL, do the following (or similar lab activities). Try to time these so that students are at the point where they need to know these concepts.

Addition of Force Lab, found at <http://physics.uwstout.edu/Staff/mccullough/ForceEquil.pdf> or <http://www.math.mtu.edu/gk-12/Vector.pdf> Additionally, most texts will include a lab on this topic which may be used. (Evaluate with [Addition of Force lab report rubric](#))

Motion of a Projectile Lab, found at <http://www.math.mtu.edu/gk-12/2-D%20Motion.pdf> (use Part A: Motion of a Dart) Additionally, most texts will include a lab on this topic which may be used. (Evaluate with [Motion of a Projectile lab report rubric](#))

Step 7: Students complete writing response to [Prompt \(FAT-P\) on Newton's Laws](#).

Step 8: Students complete individual video analysis of a motion.

Step 9: Students create the documentary video.

Step 10: Students conduct a peer review of team products, using the documentary and content video rubrics to evaluate their own video and those of other groups. Discuss suggestions for making the videos better.

Step 11: Allow teams the opportunity to make changes to documentary videos and finalize these.

Step 12: Students share the documentaries with an audience. The audience can include coaches and athletes involved in the selected sports as well as physics "experts". The audience can also be virtual by posting the videos online, on school server, or by showing with internal school TV system.

Project Evaluation:

Individual and group products will be evaluated using the rubrics, checklists, and observations described earlier.

Debrief students through writing and discussion ([Self Reflection](#)).

Resource Files Uploaded

Resource Files

- UP3399WS2.doc
(<http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3399WS2.doc>)
- UP3399WS3.doc
(<http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3399WS3.doc>)
- UP3399WS4.doc
(<http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3399WS4.doc>)
- UP3399WS5.doc
(<http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3399WS5.doc>)
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- UP3399WS15.doc
(<http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3399WS15.doc>)